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BOTANY.—*Twelve new American Asteraceae.*[1] S. F. BLAKE, Bureau of Plant Industry.

This paper contains descriptions of twelve new species of American Asteraceae which have been found in the course of identification of material of that family recently received at the United States National Museum and among specimens lent for study by the curators of the Kew Herbarium, the British Museum of Natural History, and the Museum d'Histoire Naturelle, Paris. A few new names and transfers are also included.

Erigeron porteri Blake, nom. nov.

Erigeron glandulosum Porter in Porter & Coulter, Syn. Fl. Colo. 60. 1874. Not *E. glandulosum* Walt. Fl. Carol. 205. 1788, nor Poir. Encycl. **8**: 487. 1808, nor Hegetschw. Fl. Schweiz 840. 1840.

The name *Erigeron glandulosus* Porter, in common use for a plant of Colorado and Wyoming, is not available for this species owing to the previous use of the same specific name by Walter, Poiret, and Hegetschweiler. Walter's name, omitted from the Index Kewensis and not referred to in Gray's Synoptical Flora, seems from description to refer to *Chrysopsis mariana*. Poiret described under the same name the plant now known as *Chrysopsis graminifolia* (Michx.) Ell., citing Michaux's name (*Inula graminifolia*) and Walter's as synonyms, the latter with doubt. Hegetschweiler's homonym is retained by Schinz and Thellung for a species of *Erigeron* of the Swiss Alps. The last name was omitted from the original volumes of the Index Kewensis, but is included in the fifth supplement, where its date is wrongly given as 1839.

Rumfordia guatemalensis (Coulter) Blake.

Tetragonotheca guatemalensis Coulter, Bot. Gaz. **16**: 99. 1891.
Rumfordia verapazensis Blake, Contr. U. S. Nat. Herb. **22**: 609. 1924.

The type of *Tetragonotheca guatemalensis* Coulter (*J. D. Smith* 1592, Senahú, Dept. Alta Verapaz, Guatemala), recently given by Capt. John

[1] Received November 23, 1927.

Donnell Smith to the U. S. National Herbarium, is the same species as *Rumfordia verapazensis* Blake, described from the Finca Sepacuité, in the same Department. The lower leaves have deltoid, membranous blades, about 18 by 18 cm., acuminate, cordate at base, hastately about 2-toothed on the basal lobes with short, acuminate teeth 1–1.5 cm. long, and with 1 or 2 small deltoid teeth on each side above the base; the petioles are 10–11 cm. long, narrowly cuneate-winged to base.

Aspilia quinquenervis Blake, sp. nov.

Shrub; branches densely strigose; leaves lance-ovate or oblong-ovate, large, long-acuminate, rounded at base, obscurely serrulate, 5-plinerved, strigose or antrorse-hirsute on both sides, on naked petioles; heads medium-sized, in a terminal cyme of 3, radiate, yellow; involucre 6–8 mm. high, slightly graduate, the outer phyllaries obovate, strigose and ciliate, the loose ovate acutish herbaceous tips about equaling the indurate base; rays short, little exceeding the involucre; pappus without awns.

"White-wooded shrub, the branches thin, up to 5 m. long," striatulate, about 3.5 mm. thick, strigose with tuberculate-based hairs; internodes 3.5–6 cm. long; leaves opposite; petioles slender, tuberculate-strigose, sulcate above, 7–15 mm. long; blades 10.5–18 cm. long, 3–6 cm. wide, serrulate (teeth short, callous, 4–8 mm. apart), papery, above dull green, evenly and somewhat harshly tuberculate-strigose or antrorse-hirsute, beneath scarcely lighter green, antrorse-hirsute on veins and surface with scarcely tuberculate-based hairs, quintuplinerved, the two pairs of lateral veins arising within 1.5 cm. above base of blade, the principal veins prominulous on both sides, not obviously reticulate; heads (rather young) about 1.4 cm. wide, in a terminal 3-headed cyme and solitary in the uppermost axils, on slender strigose peduncles 2–4 cm. long; disk 8–9 mm. high, 7–9 mm. thick; involucre campanulate-subglobose, 6–8 mm. high, 3–4-seriate, the phyllaries rather few, the 2–3 outer series obovate to oval-obovate, 3–5 mm. wide, below indurate, strigose, and ciliate, the equal or longer herbaceous tips loosely spreading, obscurely callous-tipped, strigose and strigillose on both sides, the inner phyllaries scarcely longer, with essentially glabrous or obscurely strigillose, short-ciliate, ampliate, submembranous tips; rays about 8, yellow, neutral, the lamina about 5.5 mm. long; disk corollas puberulous on teeth, otherwise glabrous, 5.2 mm. long (tube 1.5 mm., throat 3 mm., teeth 0.7 mm.); pales obtusely acuminate, about 8 mm. long, keeled, ciliolate on keel and margin, otherwise glabrous; disk achenes (immature) nearly linear, 5.5 mm. long, densely pilose above, glabrous toward base; pappus a crown of lacerate, ciliate, connate squamallae about 0.5 mm. long and 2 trigonous, ciliate teeth about 1 mm. long.

COLOMBIA: In bushes, Rio Palace, highlands of Popayán, alt. 1500–1800 m., February, *Lehmann* (type in Kew Herb.; photog. and fragm., U. S. Nat. Herb.).

Allied to *A. nigropunctata* Blake and *A. retroflexa* Blake, but distinguished from both by characters of leaves and involucre.

Simsia grayii Sch. Bip., sp. nov.

Stem densely spreading-hispidulous and sparsely spreading-setose; leaves opposite, triangular-ovate, hastate-lobed, finely hispidulous and sparsely setose, the petioles winged throughout, connate at base into foliaceous

disks; heads radiate, yellow, the disk turning purple; involucre 3–4-seriate, strongly graduate, 7 mm. high; achenes 4 mm. long, 2-awned.

Herb; stem slender, oppositely branched above with divergent or wide-spreading branches; internodes 10.5–13 cm. long; petioles 2–3 cm. long, narrowly or broadly winged to base and there dilated and connate into foliaceous disks 7–12 mm. wide; blades triangular-ovate, 6–8.5 cm. long, 3–5 cm. wide, acuminate, at base subtruncate and then shortly cuneate into the petiole, hastately lobed (lobes short, broadly triangular, obtusish), crenate-serrate except at base and apex with short callous-apiculate teeth, rather thin, above densely and harshly hispidulous and sparsely setose, beneath somewhat paler, densely and finely spreading-hispidulous, setose along the chief veins, triplinerved at base and prominulous-reticulate beneath; leaves of the inflorescence smaller, not hastate, often alternate, mostly lanceolate, their short petioles margined and at base auriculate but not connate; heads about 12 mm. wide, in cymes of 2–5 at tips of stem and branches, on very slender naked pedicels 2 cm. long or less; disk campanulate, 8–10 mm. high, 8 mm. thick; phyllaries lance-triangular (0.5–1.3 mm. wide), acuminate, with short loose subherbaceous tips, densely and finely hispidulous, tuberculate-setulose at tip, the outer very sparsely setose chiefly along midline, the inner about 5-nerved; rays 8, yellow, the lamina elliptic, 4.5 mm. long; disk corollas yellow turning purple, stipitate-glandular on tube, finely hispidulous on throat and teeth, 7 mm. long at maturity (tube 1.3 mm., throat cylindric, 4.7 mm., teeth ovate, 1 mm.); pales acute or acuminate, hispidulous, at apex short-hispid, 7–8 mm. long; achenes oval, blackish, erect-pilose, ciliate, 4 mm. long, 2.5 mm. wide; awns 2, subequal, hispidulous, 2.3 mm. long.

MEXICO: Tepinapa, Oaxaca, Oct. 1842, *Liebmann* 560 (herb. Sch. Bip.; photog. and fragm., U. S. Nat. Herb.). Province of Oaxaca, *Liebmann* 561 (type in herb. Sch. Bip.; photog. and fragm., U. S. Nat. Herb.). Province of Oaxaca, *Buchinger* 497 (herb. Sch. Bip.).

Related to *Simsia setosa* Blake, of Sonora, *S. tenuis* (Fernald) Blake, of Guerrero, and *S. holwayi* Blake, of Guatemala; distinguished by its combination of sparsely setose stem, hastately 3-lobed leaves, these short-pubescent beneath and with petioles margined to base, and small heads. The specimen collected by Buchinger, labeled by Schultz in 1852 as a new species under a different name, was placed in the same cover in the Schultz herbarium with *Liebmann* 560 and 561, which he named *Simsia grayii* in 1854.

Zexmenia mexiae Blake, sp. nov.

Suffrutescent, ternately branched, strigose and strigillose throughout; leaves ovate, short-petioled, acuminate, rounded at base, serrate, 5-plinerved, the blades about 8 cm. long; heads radiate, medium-sized, mostly in terminal cymes of 5–9, on pedicels usually 3–5 cm. long; involucre strongly graduate, about 8 mm. high, appressed, the phyllaries suborbicular-ovate to oblong-oval, the outer shortly callous-pointed, the inner rounded; achenes very narrowly wing-margined; pappus of 2 awns equaling the achene and a crown of basally connate squamellae 1.5 mm. long or less.

Plant 2 m. high; stem subterete, striate, gray-brown, about 4 mm. thick, rather densely strigose and strigillose with slightly tuberculate-based hairs;

internodes 8–12 cm. long; leaves opposite; petioles naked, densely strigose, strigillose, and hispid-ciliate, 3–6 mm. long; blades 6–9 cm. long, 3–4.3 cm. wide, broadly rounded or subcordate at base, serrate (teeth acutely callous-tipped, about 0.5 mm. high, 3–7 mm. apart), pergamentaceous, above more or less shining green, strigillose on surface with scarcely tuberculate-based hairs, strigose along the veins, beneath duller green, strigillose on surface and veinlets, strigose along the veins, somewhat bullate above, loosely prominulous-reticulate beneath; heads 2 cm. wide, in terminal cymes, and solitary or in clusters of 2–3 in the upper axils, the slender densely strigillose pedicels 1.5–7 cm. long; disk campanulate, 1–1.4 cm. high, 7–10 mm. thick; involucre about 5-seriate, 8–9 mm. high, 7–9 mm. thick, the outer phyllaries broadly ovate or suborbicular, abruptly and acutely callous-pointed, densely strigose, strigillose, and short-ciliate, with indurate base or lower margin and greenish apex, about 4.5 mm. long, 3–4 mm. wide, the middle ones similar but longer and broader, the inner oblong-oval, 4.5–5 mm. wide, strigillose, with short-ciliate, erose, broadly rounded, submembranous tips; rays 13, pistillate, golden-yellow, glabrous, the tube 3 mm. long, the lamina elliptic, 9 mm. long, 3 mm. wide, about 11-nerved, tridenticulate; disk flowers about 63, their corollas golden yellow, much exserted at maturity, glabrous outside, 6.5–8 mm. long (tube 2–2.7 mm., throat slender-funnelform, 4–4.5 mm., teeth ovate, papillose-margined inside, 0.8 mm. long); receptacle flattish; pales narrow, 8 mm. long, carinate, hispidulous-ciliolate on keel and toward apex, tridentate, the middle tooth obtuse, about 2 mm. long, flattish, the lateral ones short; ray achenes trigonous, 3-aristate (inner awn longest, about 2.5 mm. long), narrowly 3-marginate-winged, otherwise essentially similar to disk achenes; disk achenes narrowly obovate, strongly compressed, very narrowly wing-margined, 4.5 mm. long, 1.5 mm. wide, blackish, obscurely strigillose at apex, spinulose-ciliolate on wings, the wings adnate at base to the 2 awns, these unequal, spinulose, 3.5–4.5 mm. long, connected at base by a crown of basally connate squamellae 0.5–1.5 mm. long.

MEXICO: In woods, Palapar Redondo, Tuxpan, Jalisco, alt. 20 m., 5 Nov. 1926, *Ynes Mexia* 1049 (type no. 1,317, 609, U. S. Nat. Herb.).

Nearest *Zexmenia microcephala* Hemsl., which has much smaller, fewer-flowered heads on pedicels only 1–2 cm. long. Described by the collector as a large, coarse, erect, showy plant, with the vernacular name "tacote amarillo."

Otopappus cordatus Blake, sp. nov.

Stem and pedicels strigillose; leaves ovate, cordate, slender-petioled, 3-nerved from base, repand-dentate, rough on both sides; heads medium-sized, solitary at apex of stem and in upper axils on widely spreading pedicels about 2.5 cm. long; outer phyllaries spatulate, with spreading herbaceous tips; rays about 32, about 3 mm. long.

Shrub; branch slender, densely cinereous-strigillose with somewhat tuberculate-based hairs; leaves opposite throughout; internodes 5–7 cm. long; petioles naked, subterete, shallowly sulcate above, densely strigillose, 1.5–2.7 cm. long; blades ovate, 8.5–11 cm. long, 4.5–8 cm. wide, acuminate, cordate at base (sinus 1.2 cm. deep or less) or the upper subtruncate, repand-dentate and denticulate with unequal callous teeth essentially throughout (teeth 3–5 mm. apart), or the uppermost merely denticulate, pergamentace-

ous, above deep green, densely and harshly antrorse-hispidulous with glandular-tuberculate-based hairs, impressed-veined and subbullate, beneath lighter green, densely antrorse-hispidulous on all veins and veinlets, gland-dotted, 3-nerved from base and densely prominulous-reticulate, the principal veinlets for the most part diverging at a right angle from their respective veins; heads 9, 1.2–1.5 cm. wide, the lower in the axils of foliage leaves, the uppermost subtended by narrowly lanceolate bracts 2.5 cm. long; disk in flower about 9 mm. high, 12 mm. thick; involucre broadly campanulate, 4–5-seriate, graduate, 6 mm. high, the 2 outermost series of phyllaries spatulate, 3–5 mm. long, 1–1.5 mm. wide, with subindurate base and longer, obtuse, spreading, herbaceous tip, 1-ribbed, strigillose, the 2–3 inner series oblong, obtuse to acute, erect, with obscurely greenish, densely strigillose center and narrow, golden-yellow, subscarious, glabrous margin; rays about 32, fertile, golden yellow, sub-2-seriate, spreading, the tube glabrous, 0.5 mm. long, the lamina oval, bidentate, pilosulous on nerves of back, 7-nerved, 3 mm. long, 2 mm. wide; disk corollas numerous, golden yellow, essentially glabrous outside, barbellate within toward apex of teeth, 3.8 mm. long (tube 0.5 mm., throat slender-funnelform, 2.7 mm., teeth ovate, 0.6 mm.); pales very narrow, keeled, 5.5 mm. long, with firm, acute, yellow, hispidulous-ciliolate tips; ray achenes (submature) trigonous, 3 mm. long, 3-winged, the wings hispidulous-ciliolate, adnate throughout to the 3 awns, these 0.8–1.4 mm. long, connected by a crown of connate lacerate squamellae up to 0.4 mm. long; disk achenes (submature) compressed, the body narrowly obovate, glabrous, 3 mm. long, 0.8 mm. wide, 2-winged, the outer wing glabrous, narrow, adnate to the hispidulous-ciliolate awn (this 1.7 mm. long), the inner wing hispidulous-ciliolate, much broadened above and adnate to the awn (this 2 mm. long); squamellæ united into a lacerate crown 0.6 mm. long, adnate below to the awns.

MEXICO: Achotla, Guerrero, alt. 900 m., Oct. 1926, *B. P. Reko* 5011 (type no. 1,269,429, U. S. Nat. Herb.).

Nearest *Otopappus salazari* Blake, but with much broader, deeply cordate, strongly reticulate, conspicuously toothed leaves, fewer and larger heads, and much shorter and more numerous rays.

Oyedaea obovata Blake, sp. nov.

Stem and branches densely appressed-pubescent; leaves elliptic-ovate or ovate, short-petioled, acute, rounded at base, obscurely serrulate, roughish above with subappressed hairs, hirsute beneath, featherveined, about 6 cm. long; heads medium-sized, short-pedicelled, in close clusters of 3–6 at tips of stem and branches; involucre 1–1.2 cm. high, the outer phyllaries with indurate base and abruptly broader, suborbicular-ovate, acute, herbaceous tip.

Shrub; branches alternate or opposite; stem stout (3–5 mm. thick), subterete, striatulate, at length glabrescent, the branches erectish, subangulate, densely and griseously appressed-pubescent or substrigose; internodes 1–3.5 cm. long; petioles stout, naked, pubescent like the stem, 5–9 mm. long; blades 4.5–7 cm. long, 2–3 cm. wide, broadly rounded to cuneate-rounded at base, obscurely serrulate (teeth minute, 2–4 mm. apart) on the slightly revolute margin, subcoriaceous, above deep green, shining, densely and finely tuberculate, more sparsely (along chief veins densely) antrorse-hirsute, beneath evenly and rather densely hirsute on surface and veinlets with

spreading antrorse-curved hairs, along the chief veins antrorse-hirsute with stouter hairs, prominulous-reticulate beneath, the chief lateral veins 7–8 pairs, a pair about 1–1.5 cm. above base of leaf often more conspicuous than the others and frequently forked; heads 2.2–3 cm. wide, in close cymose clusters, usually overtopped by the leaves, the stout pedicels 1–12 mm. long, densely pubescent like the stem or the hairs sometimes spreading; disk about 1 cm. high and thick; involucre campanulate, about 5-seriate, graduate, 1–1.2 cm. high, the 2 outermost series of phyllaries obovate or broadly spatulate-obovate, with indurate base (1.5–3 mm. wide) and abrupt, subequal, suborbicular-ovate, thick-herbaceous, erect or rather loose tip (3–5 mm. wide), subappressed-hirsute, more or less ciliate, and somewhat tuberculate, the middle ones elliptic-oblong or oblong (3–4 mm. wide), with somewhat ampliate, subscarious, broadly rounded tip, less pubescent, the innermost sometimes shorter, subglabrous or sordid-glandular, with subscarious tip; rays about 10, yellow, neutral, the tube 2 mm. long, the lamina oblong, 2-dentate, about 12 mm. long, 4 mm. wide, about 12-nerved, puberulous on nerves of back; disk corollas numerous, evidently yellow, finely hispidulous on teeth, otherwise glabrous, 5.7 mm. long (tube 2 mm., throat subcylindric, 3 mm., teeth ovate, 0.7 mm.); pales narrow, acute, carinate, obscurely ciliolate toward apex, 8 mm. long; disk achenes oblong-obovate, 4 mm. long, 1.5 mm. wide, compressed, very narrowly 2-winged, sparsely appressed-pubescent on sides, short-ciliate; pappus a lacerate-ciliolate crown of squamellae 0.8 mm. long and 2 slightly unequal, slender, hispidulous awns 3 mm. long.

VENEZUELA: Agua de Obispo, Province of Trujillo, alt. 2135–2440 m., July 1843, *Linden* 1450 (type in herb. Mus. Paris, dupl. in herb. Sch. Bip.; photog. and fragm., U. S. Nat. Herb.).

In Schultz's herbarium this plant was marked as a new species of *Leighia* (= *Viguiera*), under a name which it has not seemed necessary to cite, with a note indicating that Schultz suspected it might represent a new genus. The specimen in the Paris Herbarium is marked "*Viguiera?*" in Bentham's hand. The plant is definitely an *Oyedaea* near the Colombian *O. reticulata* Blake, but with denser pubescence, somewhat different leaves, and very different, highly characteristic phyllaries.

Verbesina pantoptera Blake, sp. nov.

Perennial herb, 60 cm. high, simple, 4–7-headed, hispidulous throughout; stem and peduncles very narrowly 4-winged throughout; leaves opposite to middle of stem, the blades ovate, sometimes hastately 3-lobed with obtuse lobes, acute, rounded or abruptly contracted into narrowly cuneate-winged petioles, denticulate, rough-pubescent on both sides, the blade about 5 cm. long; involucre obgraduate, loose, herbaceous, 1–1.2 cm. high, the phyllaries linear or lance-linear; rays about 13, lemon-yellow, the lamina about 1.2 cm. long.

Rootstock short (ca. 2 cm. long); stems apparently few, about 2 mm. thick, spreading-hispidulous, the 4 herbaceous wings entire, scarcely 1 mm. wide; larger leaves about 5 pairs, subremote (internodes 3.5–7 cm. long), the blades 5–6 cm. long, 2.8–3.8 cm. wide, firm-papery, dark dull green above, paler dull green beneath, above evenly tuberculate-hispidulous or short-hispid, beneath rather densely hispidulous on veins and veinlets,

featherveined or obscurely triplinerved, the veins and veinlets prominulous-reticulate beneath, the petioles cuneate-winged to base, not connate, 1.2–2 cm. long, 6–8 mm. wide above, 1.5 mm. wide at base; upper leaves few (about 4), mostly alternate, lanceolate to triangular-ovate, 0.8–2 cm. wide, acuminate, acutely cuneate at base, unlobed; peduncles terminal and in the upper axils, 1–3-headed, 2–9 cm. long, the terminal one shortest; heads 2–3 cm. wide, apparently nodding except at maturity; disk 8–10 mm. high; involucre about 3-seriate, obgraduate, the outermost phyllaries linear or linear-lanceolate, acute or obtuse, callous-tipped, herbaceous essentially throughout, hispidulous or short-hispid on both sides, loose, in age reflexed from above the base, 10–12 mm. long, 1.5 mm. wide, the second series similar but shorter, 8–10 mm. long, the innermost (subtending the rays) still shorter, herbaceous above, subindurate below, acuminate; rays neutral, "lemon yellow," sparsely hirsutulous on tube and back, the tube 1.5–2.5 mm. long, the lamina elliptic, 1.1–1.3 cm. long, about 4 mm. wide, 8–9-nerved, 2–3-denticulate; disk corollas numerous, "lemon yellow," hispidulous chiefly above the middle, 7.5 mm. long (tube 1 mm., throat subcylindric, 5.3 mm. long, teeth 1.2 mm.); pales rather narrow, about 7 mm. long, hispidulous on keel and toward tip, tridentate, the lateral teeth short, the middle one elongate, nearly equaling body of pale, greenish, with slightly recurved tip; achenes (submature) broadly and obliquely obovate, 4 mm. long, 3 mm. wide including wings (these 0.2–0.3 mm. wide), very flat, 1-nerved on each side, glabrous except for the short-ciliate wings, the wings adnate at base to the awns and connected between them by a narrow undulate margin; awns 2, subulate, hispidulous, slightly unequal, 1.2–1.5 mm. long.

MEXICO: Common in open spaces in woods on lower slope of Cordilleras, trail from Tepic to Santiago, State of Nayarit, alt. 1000 m., 15 Sept. 1926, *Ynes Mexia* 632 (type no. 1,317,608, U. S. Nat. Herb.).

A species of the section *Pterophyton*, readily distinguished by its narrowly winged stems and peduncles, in combination with its comparatively long, herbaceous phyllaries. The undulate margin connecting the awns suggests the allied genus *Zexmenia*, but a longitudinal section of the achene indicates that this border is not squamelloid in origin, but is formed by the lateral confluence of the substance of the wings between the awns, which are embedded in it, and around the contracted apex of the achene body. In any case the neutral rays forbid the reference of the species to *Zexmenia*.

Verbesina heterocarpa Blake, sp. nov.

Shrub; stem softly griseous-puberulous with subappressed hairs; leaves of main stem alternate, of branches opposite, lanceolate, about 8 cm. long, acuminate at each end, short-petioled, serrulate, roughish above, softly griseous-pilose-subtomentose and densely dotted with yellow glands beneath; heads rather small, several in small terminal panicles, radiate, yellow; involucre 4–5-seriate, the inner phyllaries with acuminate subscarious tips; pales with yellowish erect acuminate scarious tips; ray achenes glabrous, their pappus of a single squamella; disk achenes pubescent, 2-awned.

Shrub 2.5 m. high, the branches alternate or opposite, about 3 dm. long; main stem subterete, 4 mm. thick, finely appressed-puberulous; branches fuscous, densely subappressed-puberulous and with some not longer more or

less spreading hairs and finely gland-dotted, their internodes usually 2–4.5 cm. long; petioles naked, unappendaged, pubescent like the stem, 4–5 mm. long; blades 7–8 cm. long, 1.3–1.8 cm. wide, serrulate (teeth small, callous, mostly deflexed, 2–3 mm. apart), pergamentaceous, above dull green or purplish-tinged, densely antrorse-hirsutulous with slightly tuberculate-based hairs and gland-dotted, beneath densely pilose-subtomentose with mostly spreading hairs and gland-dotted, featherveined, the lateral veins about 15 pairs, prominulous beneath, the veinlets scarcely prominulous; heads about 1 cm. wide, in flattish or convex panicles (about 3–6 cm. wide) of 15–24 at apex of branches, the bracts lance-linear, mostly 3.5 cm. long or less, the pedicels slender, 5–15 mm. long, pubescent like the stem; involucre 4–5-seriate, strongly graduate, 5–6 mm. high, the outer 2 series of phyllaries ovate, 0.5–1.2 mm. wide, appressed, pilosulous and gland-dotted, subherbaceous above, with short, acutish, purplish, callous tips, the others ovate or lance-ovate, 1.3–2 mm. wide, with subindurate central portion and subscarious, yellowish, sharply acuminate, erect tips, usually fuscous centrally, sparsely pilosulous and dotted with sessile yellow glands; rays 6, golden yellow, pistillate, pilose and stipitate-glandular on tube and base of back, the tube 1.5 mm. long, the lamina oval, emarginate, 6 mm. long, 4–4.5 mm. wide; disk flowers 22, their corollas golden yellow, pilose and stipitate-glandular on tube, sparsely pilose on nerves of throat below, papillose on inner surface of teeth, 6 mm. long (tube 1.5 mm., throat subcylindric, 3.5 mm., teeth ovate, 1 mm.); receptacle strongly convex; pales similar to the inner phyllaries in shape and texture, about 7 mm. long, stipitate-glandular on back and above on margin and very sparsely pilose on back, with scarious, yellowish, sharply acuminate, erect or somewhat incurved tips; ray achenes (very immature) obcompressed or trigonous, glabrous or with a few hairs at apex, narrowly 2-winged, their pappus of a single squamella 0.3 mm. long or less; disk achenes (very immature) compressed, narrowly obovate, 3 mm. long, very narrowly 2-winged, pilosulous above, densely short-ciliate on wings; pappus awns 2, slender, unequal, hispidulous, 2.5–3.2 mm. long.

MEXICO: In opening in oak forest on steep slope, Real Alto, Sierra Madre Occidental, Jalisco, alt. 2500 m., 29 Jan. 1927, *Ynes Mexia* 1587 (type no. 1,317,611, U. S. Nat. Herb.).

A member of the section *Saubinetia*, allied to *V. molinaria* Robins. & Greenm. and *V. oncophora* Robins. & Seaton. In the former the larger, opposite leaves are canescently subsericeous-tomentose beneath, and the involucre and pales are very different; in the latter the leaves are larger and normally alternate, the petioles are provided at base with deciduous corky auricles, the involucre is shorter and simpler, and the much shorter, firmer pales bear abrupt short mucros. The almost complete absence of pappus in the ray flowers of *V. heterocarpa* is a striking feature not found in either of the two related species.

Verbesina glaucophylla Blake, sp. nov.

Shrubby, leafy, glabrous throughout except for the obscurely puberulous pedicels; leaves chiefly alternate, lanceolate, 9–20 cm. long, acuminate at each end, short-petioled, denticulate, green above, glaucous beneath; heads discoid, whitish, about 36-flowered, slender-pediceled, numerous in a terminal concave cymose panicle; involucre 2–2.5 mm. high; pales with short recurving mucros.

Shrub 1.5–2.5 m. high; stems or branches subterete, simple or little branched, striate, glabrous, glaucescent, 3 mm. thick, pithy; internodes 5–15 mm. long; leaves alternate, or on short branches opposite below, the blades lanceolate, 1.8–3.5 cm. wide, broadest near middle, subremotely denticulate or serrulate-denticulate (teeth blunt, callous, ca. 0.4 mm. high, 3–11 mm. apart), papery to subpergamentaceous, glabrous and smooth on both sides featherveined (lateral veins about 10 pairs), finely translucent-reticulate, the strong costa whitish or purplish, the chief lateral veins prominulous; naked portion of petiole grooved above, 3–7 mm. long; heads turbinate-hemispheric, about 8 mm. high, 10 mm. wide, on terminal and axillary peduncles 7.5 cm. long or less, forming a panicle about 11 cm. wide, the bracts mostly narrowly linear, 2–20 mm. long, the pedicels mostly 8–25 mm. long, slightly puberulous especially at apex; involucre 2-seriate, subequal, the phyllaries ovate or oblong-ovate, obtuse, glabrous, subherbaceous, sometimes subtended by a few slightly longer and more herbaceous loose-tipped bracts; corollas whitish, 3.5–4 mm. long (tube densely pilose, 1–1.2 mm., throat glabrous, thick-cylindric, 1.8–2 mm., teeth ovate, short-ciliate on inner margin, 0.7–1 mm. long); receptacle convex; pales cymbiform, yellowish green, 3.5–4 mm. long, strongly carinate, sparsely hispidulous on keel, denticulate on the subscarious margin above, tipped with a short erect or recurving mucro; achenes obovate, 2.6 mm. long, 2.8 mm. wide (including wings), the body blackish, sparsely pilose near apex, about 1.2 mm. wide, the short-ciliate whitish wings about 0.7 mm. wide, prolonged above the achene and adnate to base of awns, the awns 2, subequal, hispidulous, 2 mm. long.

MEXICO: In pine forest on steep dry clay hills, Loma de Garote, trail to San Sebastian, Sierra Madre Occidental, Jalisco, alt. 1500 m., 8 Feb. 1927, *Ynes Mexia* 1649a (type no. 1,317,612, U. S. Nat. Herb.). San Sebastian, east of Arroyo Santa Gertrudis, Jalisco, 17 Jan. 1927, *Mexia* 1507.

A species of the section *Lipactinia*, distinguished by its glabrous character, its glaucescence, and its about 36-flowered heads. The two other Mexican species of this section have 7–9-flowered heads.

Verbesina rivetii Blake, sp. nov.

Stem thinly cinereous-tomentose; leaves alternate, short-petioled, oblong-lanceolate, acuminate, acutely cuneate at base, sharply serrulate, cinereous-tomentose beneath; heads small, 15–17-flowered, radiate, yellow, very numerous in a large flattish terminal panicle; outermost phyllaries oblong, pilosulous; pales slightly ciliolate.

Shrub; stem (or branch) simple below the inflorescence, 5 mm. thick, subterete, multistriatulate; internodes 1–2 cm. long; petioles stout, naked, densely cinereous- or canescent-tomentose, 4–7 mm. long; blades 6–10 cm. long, 1.5–2.5 cm. wide, serrate or serrulate above the entire cuneate base (teeth about 7 pairs, callous-tipped, 0.5–1 mm. high, usually 5–10 mm. apart), above deep green, densely and rather harshly pilosulous with antrorse-curved hairs with persistent glandular-tuberculate bases, beneath densely and softly cinereous-tomentose, pergamentaceous, featherveined, the chief lateral veins 5–7 pairs, covered by the tomentum; heads 1–1.2 cm. wide, numerous in dense cymose panicles at tip of stem and branches, together forming a panicle 20 cm. wide, the ultimate bracts minute, the pedicels mostly 6–12 mm. long, spreading-pilosulous; disk subcylindric, 1 cm. high, 4–5 mm. thick; involucre about 3-seriate, 5–7 mm. high, the phyllaries few,

very unequal, the outermost oblong or ovate-oblong, about 2.5 mm. long, 1 mm. wide, subherbaceous, obtusish, callous-tipped, densely pilosulous, the innermost (subtending the rays), 5–7 mm. long, similar to the pales in shape and texture, ciliolate, on back glabrous or somewhat puberulous; rays 4–5, fertile, pilosulous on tube and base of lamina, the tube 2.2 mm. long, the lamina oval or suborbicular, 2–3-denticulate, about 8-nerved, 4–4.8 mm. long, 2.8–3.5 mm. wide; disk flowers 10–13, their corollas densely short-pilose on tube and base of throat, strongly papillose-bearded on margin of teeth within, 5.5–6 mm. long (tube 1.8 mm., throat funnelform, 3–3.3 mm., teeth ovate, 0.8–1 mm.); pales oblong, acute or acutish, blackish green, yellow-margined and -tipped, short-ciliate, essentially glabrous dorsally, about 8 mm. long; ray achenes compressed or trigonous, narrowly winged, their pappus of 2 subequal or very unequal more or less paleaceous awns 2.5 mm. long or less, sometimes reduced to short teeth; disk achenes cuneate-obovate, compressed, blackish, very narrowly 2-winged (wings ciliolate, about 0.1 mm. wide, adnate to base of awns), glabrous or sparsely hispidulous on the sides, 5 mm. long, 1.5 mm. wide; pappus awns 2, subequal, hispidulous, about 3 mm. long.

ECUADOR: Terme Nord, Nov. 1902, *Rivet* 290 (type, Mus. Paris, photog. and fragm., U. S. Nat. Herb.).

A member of the section *Lipactinia*, of the *Verbesina arborea* group, distinguished by its radiate heads, comparatively small sharp-toothed leaves, and merely ciliate pales. It is near the Peruvian *V. grandifolia* Blake, which has densely pubescent pales and very much larger leaves, those subtending the lower branches of the inflorescence in that species being about 2 dm. long, in *V. rivetii* 6 cm. or less.

Calea longipes Blake, nom. nov.

Tridax trianae Hieron. Bot. Jahrb. Engl. **21**: 350. 1896. Not *Calea trianae* Hieron. 1894.

This species was evidently referred to *Tridax* by Hieronymus because of its ciliate pappus awns. It has not the characteristic bilabiate ray corolla of that genus, and its pappus is much nearer that of *Calea*. The linear-lanceolate, attenuate awns have the scarious margin lacerate-ciliate, only slightly more so than in such a *Calea* as *C. caracasana*, and are by no means plumose as is the pappus of *Tridax*. The pappus of the ray flowers is much reduced and only 1 mm. long, while that of the disk reaches 3.5 mm. The species is not closely related to any other species of western South America, but comes near the Mexican *C. palmeri* Gray. I have examined two sheets of *Triana* 1422, the type number of *T. trianae*, from Anaporina (?), Bogotá, alt. 2600 meters (Brit. Mus., Kew), and another from herb. Triana (Brit. Mus.) labeled *Linden* 61. A recent specimen in the U. S. National Herbarium is *Ariste-Joseph* A773, doubtfully from the Department of Cundinamarca. *Stuebel* 176b, also cited by Hieronymus for his new species, has not been available for examination.

Gynoxys jamesonii Blake, sp. nov.

Shrub; branches sordidly stellate-tomentose, glabrescent; leaves petioled, elongate-lanceolate, acuminate, repand-denticulate, glabrous above, beneath densely stellate-tomentose with short grayish hairs and loosely brownish-tomentose with longer, somewhat deciduous, stellate hairs; heads small,

white, radiate, crowded in ternately divided panicles, 10–11-flowered; involucre 4.5 mm. high, sordidly stellate-tomentose, somewhat glabrescent; rays 5, short.

Branches somewhat compressed, striatulate; leaves opposite; uppermost internodes 4.5 cm. long; petioles naked, densely sordid-tomentose with stellate hairs, sulcate above and beneath, 1.5–2 cm. long; blades 11–15.5 cm. long, 2–3 cm. wide, rounded to cuneate at base, repand-denticulate (teeth small, callous, 1–2 cm. apart), above dark green, glabrous except for base of costa, closely prominulous-reticulate, beneath densely and doubly stellate-tomentose (the lower tomentum of very short and dense grayish hairs, the upper of much longer, more or less deciduous brownish hairs), pinnate-veined (the lateral veins about 20 pairs, prominulous-reticulate beneath); panicles terminal and pedunculate from the upper axils, convex, 5–12 cm. wide, densely stellate-tomentose with short brownish hairs, the lowest pair of bracts linear, about 2 cm. long, the others minute, subulate, 3 mm. long or less; pedicels 5 mm. long to almost none; heads numerous, somewhat fasciculate, obovoid, 6 mm. wide, the disk 7 mm. high, 3 mm. thick; bractlets at base of involucre 2–3, subulate, appressed, 1.5–2 mm. long, stellate-tomentose, persistent; phyllaries 8, equal, 1.5–1.8 mm. wide, somewhat imbricate, oblong, obtuse, the outermost densely stellate-pubescent with short brown hairs except toward base, the middle ones stellate-pubescent along midline above, the innermost glabrous except at apex; receptacle alveolate, glabrous; rays 5, fertile, glabrous, the tube 3.5 mm. long, the lamina erectish, linear-elliptic, entire, 3 mm. long, 0.6 mm. wide, about 4-nerved; disk corollas 5–6, glabrous, 5.2 mm. long (tube 2.6 mm., throat scarcely wider, 1 mm., teeth rather narrow, 1.6 mm. long); achenes (immature) glabrous, ribbed, 1.5 mm. long; pappus of numerous yellowish-white serrulate bristles 4.5 mm. long or less; style-tips subtruncate-rounded, merely papillose-hispidulous, without evident appendage.

ECUADOR: West side of Mount Pichincha, alt. 3050 m., *Jameson* 227 (type in Kew Herb.; photog. and fragm., U. S. Nat. Herb.).

Described by the collector as a shrub with white, very fragrant flowers. Related to *G. albiflora* Wedd., *G. longifolia* Wedd., and *G. seleriana* Muschl., but distinguished by characters of leaves, heads, and involucre. The double tomentum of the lower leaf surface is like that described for *G. henrici* Mattf., but the plants are otherwise very different.

Gynoxys leiotheca Blake, sp. nov.

Branches densely velvety-tomentose; leaves elliptic or oblong-elliptic, obtuse, rounded at base, subentire, coriaceous, soon glabrous and prominulous-reticulate above, densely ochroleucous-velvety-tomentose and prominulous-reticulate beneath; heads discoid, yellow, 7–8-flowered, subsessile or short-pediceled, cymose-panicled; involucre 6–7 mm. high, glabrous or essentially so.

Shrub; branches subangulate, stoutish, densely velvety-tomentose with ochroleucous or in age fuscescent hairs; leaves opposite; petioles similarly tomentose, 1–1.8 cm. long; blades 6–9.5 cm. long, 1.8–2.8 cm. wide, short-apiculate, at base rounded or obscurely cordate, obscurely repand-denticulate with small remote inflexed callous teeth, above at first velvety-tomentose, quickly glabrate and light green, coriaceous, the chief lateral veins 11–13 pairs, diverging at a very obtuse angle; panicles terminal, rounded, many-headed, about 12 cm. wide, pubescent like the stem; heads 8–10 mm. high,

subcylindric, crowded at tips of branches of panicle, the pedicels 5 mm. long or less, usually very short, the lowest branches subtended by somewhat reduced leaves; involucel of about 5 bractlets about 2 mm. long, triangular, acuminate, stiff, persistent, ciliate and somewhat tomentose; phyllaries 5–6, broadly oblong, obtuse, 6–7 mm. long, 1.8–2.2 mm. wide, substramineous, the outer about 5-nerved, the inner about 2-ribbed and with broad subscarious margin, all pilosulous-tufted at apex, on back glabrous to very sparsely pilose, especially toward apex; corollas glabrous, 8.5 mm. long (tube 3.5 mm., throat 2 mm., teeth 3 mm.); achenes glabrous, about 10-ribbed, 3.5 mm. long; pappus yellowish white, 7 mm. long.

ECUADOR: Borma, Sept. 1904, *Rivet* 671 (type, Mus. Paris; photog. and fragm., U. S. Nat. Herb.).

Distinguished by its 7–8-flowered discoid heads and practically glabrous involucre of 5 or 6 broad and blunt phyllaries. Apparently most closely allied, from description, to the radiate *G. szyszylowiczii* Hieron., of Peru.

Chuquiraga brasiliensis (Spreng.) Blake.

Ioannea brasiliensis Spreng. Neue Entd. **2**: 132. 1821.
Flotovia glabra Spreng. Syst. **3**: 506. 1826.
Chuquiragua glabra (Spreng.) Baker in Mart. Fl. Bras. 6[3]: 363. 1884 (synonymy).

Sprengel's name *Ioannea brasiliensis* of 1821, the oldest name applied to this species, was cited by him in 1826 as a synonym of *Flotovia glabra*. The change in the specific name was evidently made because of the addition in 1826 of a second Brazilian species, which he called *F. tomentosa*. The type in the Schultz Bipontinus herbarium at Paris was examined by the writer in 1925.

The generic name is usually written *Chuquiragua*, but its original spelling, which should be followed, was *Chuquiraga*, both in Jussieu's Genera (p. 178. 1789), where the genus was described without mention of any specific name, and in Gmelin's Systema,[2] where a specific name (*C. jussieui* Gmel.) was first assigned, based on Jussieu's description.

Perezia longifolia Blake, sp. nov.

Stem glabrous, simple, leafy; leaves very long, lance-elliptic to nearly linear-elliptic, acuminate, cordate-clasping, spinulose-denticulate, firm, loosely reticulate, hispidulous on the veins; heads large, about 46-flowered, mostly solitary in the axils, on short or obsolete peduncles; involucre turbinate, 2.8-3 cm. high, many-seriate, the phyllaries lanceolate, acuminate, glabrous.

Herb, probably tall; stem slender (3 mm. thick), terete, hollow, purplish, glaucescent; internodes 3–5.5 cm. long; leaves alternate, 20–30 cm. long, 4–7.5 cm. wide, closely spinulose-denticulate throughout except at apex with unequal teeth, subcoriaceous, above deep green, slightly shining, roughish with minute hairs along veins and veinlets and on margin, beneath light green, roughish-hispidulous on the venation, featherveined and loosely prominulous-reticulate on both sides, the chief lateral veins about 12–15 pairs, ascending at an acute angle; heads 1–2 in the axils of the middle and upper leaves, 3 cm. high, about 2 cm. thick, on glabrous minutely bracted peduncles 1 cm. long or usually less; involucre about 7-seriate, strongly graduate, the phyllaries erect, acuminate and subcuspidate, substramineous,

[2] Syst. **2**: 1205. 1791.

dull-purplish-tipped, 1-ribbed and several-nerved; corollas (white or purple?) bilabiate, 2.3 cm. long, one lip shortly 3-toothed, the other 2-partible to base; achenes (immature) subrostrate, densely glandular and hispidulous, 6.5 mm. long.

MEXICO: Calabaza, Jalisco, 1925, *B. P. Reko* 4872 (type no. 1,269,424, U. S. Nat. Herb.).

This striking species is related to *Perezia formosa* (D. Don) A. Gray and *P. turbinata* Lex. The former has narrow, much smaller leaves, and a different type of inflorescence. The latter, a still dubious plant, Gray's interpretation of which[2] is here followed, is loosely branched above, with slender pedicels, 20–30-flowered heads, and about 3-seriate involucre.

ZOOLOGY.—*Nemic spermatogenesis: with a suggested discussion of simple organisms,—Litobionts.*[1] N. A. COBB, U. S. Department of Agriculture.

Definitions. Spermatidium: one of a plurality of cells derived from a spermatid by subdivision; a secondary, tertiary, or quaternary, etc., spermatid. *Spermule:* an individual spermatidium which, after growth and transformation, is capable of activating or fertilizing an egg,—being *not* a metamorphosed spermatid, but a descendant of a spermatid, one or more cell-generations removed.

Spermatogenesis. At the blind end of the single testis of the nema, *Spirina parasitifera* (Bastian '65) Filipjev (Figs. 1 and 2),—a free living marine species, common an inch or two deep in sand and among small stones between the tide marks of protected coasts on both sides of the North Atlantic through a wide range of latitude,—the primordial gonic elements give rise by 14-chromosome mitotic division to numerous twin cells (Figs. 2, 14), which arrange themselves tandem in the testis (Fig. 3) where each

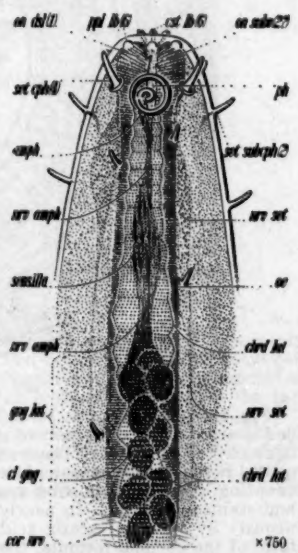

Fig. 1.—Lateral view of the head of *Spirina parasitifera*. The amphidial nerve, *nrv amph*, expands into a sensilla, then again into a 10–12 celled ganglion (seen through the lateral chord, *chrd. lat.*) joining the nerve-ring, *cor nrv*.

[2] Proc. Amer. Acad. 19: 58. 1883.

[1] The investigations were made in part at the laboratories of the U. S. Bureau of Fisheries at Woods Hole, Mass. Received December 3, 1927.

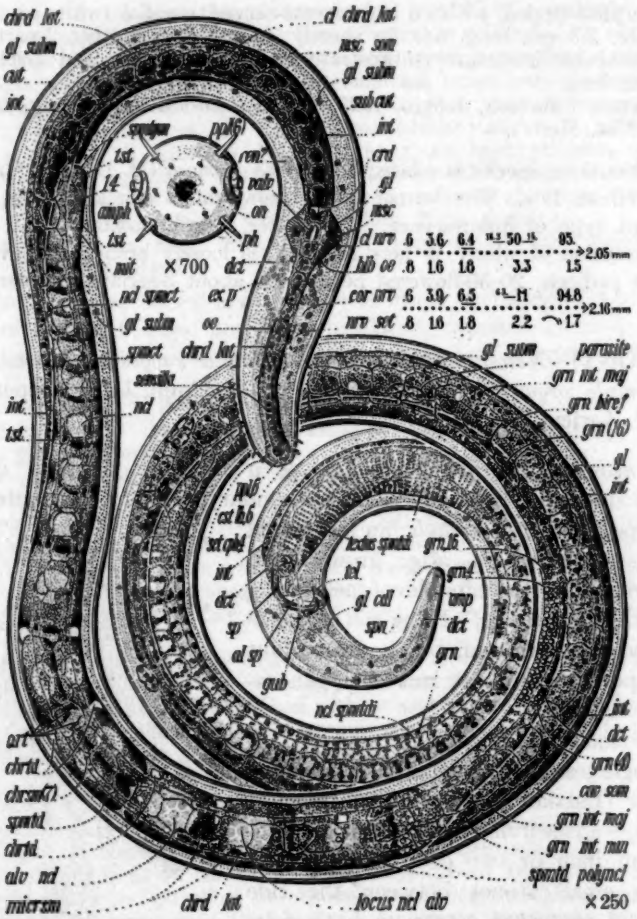

Fig. 2.—The male of *S. parasitifera* drawn from life. The tinting of drawing modified in accordance with study of stained specimens. Nearly all details shown were seen in the living specimen. The front view of head, however, is from a decapitated specimen. In life the chromosomes have not been seen definitely enough to admit of accurate counting. Most of the subsequent camera lucida drawings were obtained from fixed and stained material. In nearly all cases the fixing and staining were done simultaneously by means of acetic acid methyl green. Just to the right are placed, in the form of the decimal formula, the average measurements of specimens used. Material collected at Woods Hole, Mass., U. S. A.

The self-explanatory abbreviations are the same throughout the various figures, and are of necessary Latin anatomical terms; thus, *chrd lat*, *chorda lateralis*, lateral chord; *qrt*, quartet of spermatids; *chrtd*, chromatoids; *spmtd*, spermatid; *alv ncl*, alveoli of nuclear space; *micrsm*, microsomes, of spermatid; *14*, a 14-chromosome spermatogonial mitosis; *mit*, mitotic figure; *grn*, a cell of primary spermatidian tissue containing four granules; *grn 16*, cell of spermatidian tissue containing sixteen granules; *locus ncl alv*, locus of the diminishing alveolated nuclear space; *spmtd polyncl*, polynucleate spermatid in process of becoming a 64-celled tissue; *textus spmtdi*, spermatidian tissue.

cell, growing, forms a primary spermatocyte. At the end of the growth period the primary spermatocytes, one after another, divide transversely, i.e., at right angles to the nema's body axis, and then, sometimes almost simultaneously, longitudinally, to produce four similar, juxtaposed spermatids (Fig. 2, *qrt*), each soon packed with several thousand very slightly elongate microsomes, nearly all of which are located outside the large central, faintly alveolated, diminishing nuclear space. (Fig. 2, *micrsm* and *alv ncl;* and Fig. 14.)

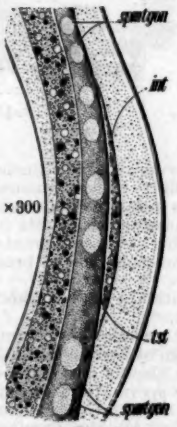

Fig. 3

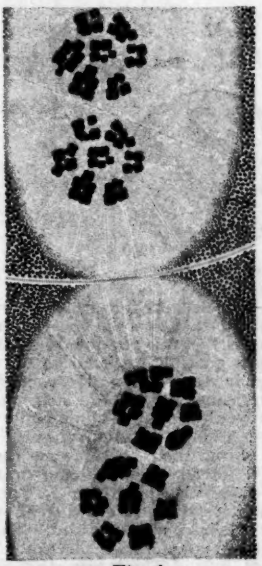

Fig. 4

Fig. 3.—View near blind end of testis of *S. parasitifera*, showing pairs of cells resulting from division of primordial nuclei. This testis had broken open and become partially evacuated so that these *pairs of cells* in tandem could readily be distinguished as such. Normally these nuclei are so packed that the mass effect obscures the fact that they are twins.

Fig. 4.—Second stage of reduction division of a spermatocyte of *S. parasitifera*, which will result in 4 similar juxtaposed spermatids, as at *qrt*, Fig. 2, each having 7 chromosomes. The compound chromosomes present considerable individuality. Between the 2 double groups of chromosomes is seen portion of the new cell wall. × 1200.

In the first of these two divisions the chromosome number is reduced to seven. Probably the smallest one of the seven chromosomes of the secondary spermatocytes differs slightly in relative size in the two cells. Thus far the spermatogenesis presents nothing very new or striking, but the amount of growth,—from 3 to 60 microns (*tst*, Fig. 2),—is worthy of note, and, connected with reduction, there is

a more or less orderly (e.g. more or less definitely oriented) extrusion from the spermatids of structureless looking chromatoid substance, (*chrtd* Fig. 2 and Fig. 14), barely possibly by a very "degenerate" mitosis; these chromatoid masses are soon absorbed.

"Normally," the four cells just described would develop into four sperms, but here the spermatogenesis proceeds as follows: Moving along the testis with soldier-like precision, the two caudad members

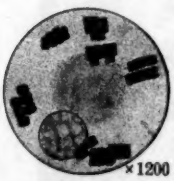

Fig. 5

Fig. 6

Fig. 7

Fig. 5.—Nucleus of full grown spermatocyte seen in synapsis. The nuclear membrane is still intact and the spherical nucleolus is still visible. The chromosomes are in seven pairs. It was possible to resolve the chromosomes into numerous components, suggesting a possible explanation of the difference in chromosome counts in certain nemas, e.g. in *Ascaris;* i.e. differences between counts at this stage and counts in later somatic divisions; for, should such loosely organized chromosomes later break apart, the count would be much increased.

Fig. 6.—A single spermatidium of first generation with its nucleus and sixteen granules. From life. In this case the cell wall is shown.

Fig. 7.—Above, camera lucida drawing of nuclei and granules in spermatidia of *S. parasitifera* at the point *grn* (4), Fig. 2. Below a diagram of four spermatidia. The diagram is derived from drawing above, and shows more clearly the numerical relationships of nuclei and granules. The boundaries of the spermatidia are almost invisible and are not shown. The granules are shown black, white or, when seen through the nucleus, gray. The larger ellipsoidal objects are nuclei. In the drawing, at top, and on the hither side, a nucleus with its accompanying four granules, the nucleus being this side of granules. In the drawing, on the farther side, again at top, a spermatidium three of whose granules have already given rise to four smaller granules each. In the drawing and below, a spermatidium none of whose four granules have divided, one of them shown behind the nucleus. *grn* (16) shows a spermatidium with a nucleus and 16 granules. The lower figure is only somewhat schematised. Very rarely are spermatidian cells so systematically arranged as to disclose so clearly the relationships of granules and nuclei. In this diagrammatic lower figure the far spermatidium is shown in an intermediate state. Illustration derived from material stained with methyl green.

of the quartet form a tandem, followed by the other two, also in tandem; i.e., the quartet falls into single file. These spermatids in file grow, and one after another divide internally without evidence of mitosis into 64 uninucleate elements which proceed to surround themselves with walls and *form a tissue of 64 cells.* (See lowest part of Fig. 2.) As this tissue leaves the testis and enters the duct it

elongates (2-4 nuclei abreast), and each of its 64 cells in turn, following on the disappearance of the microsomes, acquires four equal, refractive, spherical granules (4 microns in diameter), and the tissues thus take on a granulated appearance,—the nuclei and cell-walls being almost completely hidden by the closely packed granules. By the time the cephalad part of each tissue enters the duct the caudad part has undergone a further change, in that the four granules, *each dividing endogenously into four similar* but smaller spherical granules, populate each cell with 16 granules (*grn 4* and *grn 16*, Fig. 2).

This very interesting behavior of the granules (Figs. 7 and 9) more than suggests a different order of mechanism from that typical

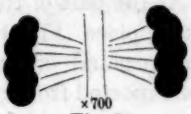

Fig. 8

Fig. 9

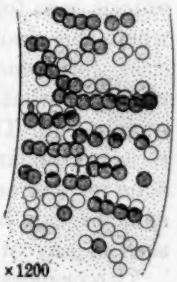

Fig. 10

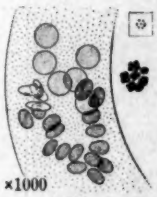

Fig. 11

Fig. 8.—Reduction division. Sublimate-acid carmine toto preparation. The smallest chromosome differed somewhat in size in the two sets. Fixation less delicate than with acid methyl green.

Fig. 9.—Two granules from the spermatidia of *S. parasitifera*;—one showing 4 smaller granules formed endogenously, the other 8. The right hand granule is from near *grn 4*, Fig. 2. The left hand granule, taken from farther back in the testis, where microscopic details are so fine that exact relationship of granules and their descendants has not as yet been fully deciphered.

Fig. 10.—Spermatidia each containing sixteen refractive spherical granules. From life. The cell walls and nuclei of this tissue are nearly invisible in life.

Fig. 11.—Nuclear spindles in later mitoses of spermatidia taking place in vas deferens. Polar views of spindles show 7 chromosomes: see small figures to right, from another part of the same specimen.

of cell division, but since irritability, ingestion, transportation, transformation and so forth, all seem involved, it appears necessary to base the concept on what is known of cell physiology and mechanics; the changes, however, are carried out on a smaller scale and doubtless with a more limited variety of molecules forming a different kind of plasm—litoplasm. In short, the facts indicate a distinctly lower order of "organism." Many of what now are often called *lower* organisms might better be regarded simply as less multiplicate. Thus certain ciliates are smaller and less multiplicate, rather than "lower," as compared with nemas for instance. This matter is

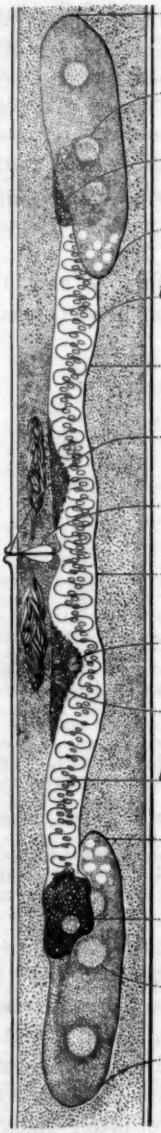

Fig. 12

briefly discussed on a later page,—under the heading, Size and Number as related to Organisms.

As the tissue proceeds along the duct, the cells containing 16 granules undergo a further diminution in the size of their granules, and a change in the number and nature of the granules, so that the cells become more transparent; at the same time the nuclei *divide mitotically*, (7 chromosomes), *giving rise to a tissue of 128 cells*. The evidence that this increase is by mitosis is as follows: 1. At the part of the duct where this change is taking place (Fig. 11) the sizes, form and position (in pairs) of the new nuclei are what would be expected from mitotic division. 2. The new smaller nuclei,—posterior to the larger, as yet undivided, nuclei,—stain more strongly. 3. Occasionally 7-element spindles can be seen. 4. No trace has been seen of any other sort of division.

Two or more such tissues as that described fill the duct of the male nema, the number of tissues varying with the age of the nema and with the copulatory history. The tissues seem to be of two styles, and, if so, perhaps correspond to the two styles of chromosomes in the secondary spermatocytes (*textus spmtdi*, Fig. 2).

Fertili ation and Syngamy. The two sexes of *S. parasitifera* seem about equally common. During copulation the male passes the spermatidian tissues on intact to the female, and afterward they may be seen in the uteri, often

Fig. 12.—Carefully proportioned free-hand sketch of gonads of female *S. parasitifera* after impregnation. The two uteri, outstretched in opposite directions, are filled with spermatidian tissue. The young ovaries are just beginning to function and the ova next the flexures, *flex ov*, are about to enter the uterus. The spermatidia adjacent to the ova about to enter the uteri have metamorphosed into spermules, *spml*, and have taken on the form characteristic of nemic sperms as hitherto described. In this case two other cells of the spermatidian tissue nearer the vulva have also begun to metamorphose. *trm*, blind end of ovary; *flex ov*, flexure of ovary; *txt spmtd*, spermatidian tissue; *gl vag*, vaginal gland, for which see also Fig. 16.

jumbled, sometimes extended along the length of the two uteri (Fig. 12).

Fertilization is preceded by increase in size of that cell of the spermatidian tissue adjacent to the ovum next to be fertilized and its transformation into a cell, spermule, having the form, and discharging the functions, of a nemic sperm as hitherto understood;—a transformation involving a growth of about 50 per cent in diameter together with a greater growth longitudinally, and a marked change in the granulation of the cytoplasm (*spml*, Fig. 12). These transformed cells, detached one by one, fertilize the eggs in what seems a normal manner. The polocytes seem normal. The female gamete has seven chromosomes (Fig. 13).

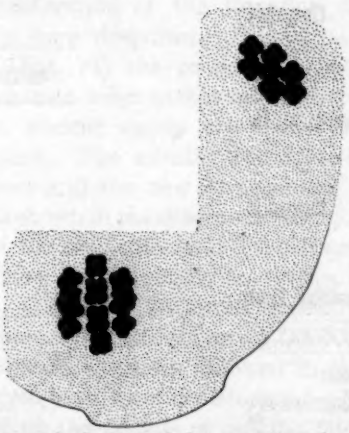

Fig. 13.—Sketch of one end of ovum of *S. parasitifera*, in synapsis. Above, male zygote. Below, female nucleus in synapsis; one group of chromosomes shown behind the other. Individuality of chromosomes obscured by their position.

This method of spermatogenesis is normal to nemas. A large number of species belonging to numerous and varied genera are known to the writer in which the general appearances in the gonad of the male so closely resemble those of *Spirina parasitifera* as to leave him no doubt that the details of their spermatogenesis will show the features here described, or something similar. The formation of the spermatidian tissue is not an essential feature; in others of the above species the spermatidia may remain separate.

Current postulates must be modified in order to account for hereditary transmission in this and similar animal species. The factors usually believed to reside wholly, or in part, in the chromosomes must here, in order to accord with the usual theories of heredity,

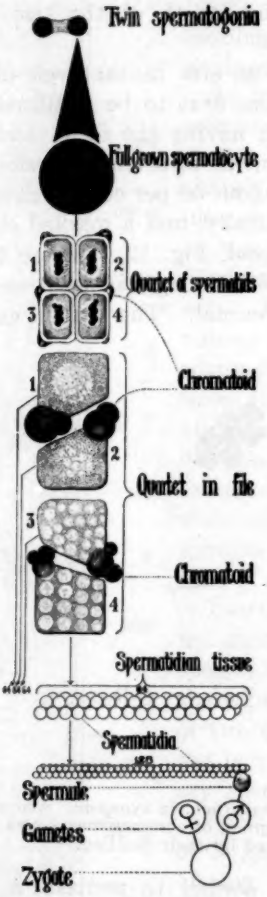

Fig. 14

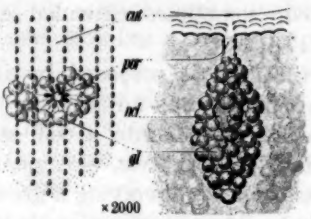

Fig. 15

Fig. 16

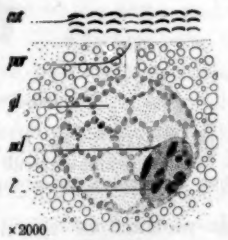

Fig. 17

Fig. 14.—Boverian diagram of spermatogenesis of *Spirina*. Spermatids are formed in the "conventional" way,—four from a spermatocyte. Instead of metamorphosing into ciliated spermatozoa, the spermatids undergo further changes and divisions, which give rise to a spermatidian tissue of 64 cells from each spermatid. These by mitotic division produce 128-celled tissues. One by one the spermatidia, when transferred to the uteri of a female, grow into spermules, capable of activating an egg and initiating normal development. Whether every one of the 128 metamorphose in this way is as yet undetermined.

Fig. 15.—Two views of one of the lateral glands of *S. parasitifera*. At the left only the pore and distal portions of gland are shown. The gland is uninucleate and consists mainly of spherical granules. Spent glands contain fewer granules than that shown.

Fig. 16.—Ventral view of vulva and vaginal glands of *S. parasitifera*. See also Fig. 12.

Fig. 17.—Lateral view of one of the lateral glands of *S. parasitifera*. The gland in a different state, or stage of development, from that shown in Fig. 4.

be "divisible" in the spermatid into numerous parts such that when they appear in the spermule they are capable of bringing about "normal" syngamy.

It will be interesting to discover how factors or genes, concepts essential to clear thinking on the subject of heredity, can be imagined to "carry on" through the mazes of the division that, extending throughout the spermatid, gives rise without mitosis to 64 apparently equivalent elements in the spermatidian tissue (see *spmtd polyncl*, Fig. 2). The spermatidian tissues (aggregates of haploid cells,—gametophores—Fig. 12) seem more clearly reminiscent of the alternation of generations in plants than any animal structure hitherto made known.

Subjoined is an alteration of the Boverian diagram illustrating the spermatogenesis here described. It will be seen that in this Boverian diagram (Fig. 14) the proportions of the camera lucida drawing (Fig. 2) are to a large extent adhered to. The microsomes and the alveolated nuclear spaces are shown with no very great departure from nature. The number and size of the microsomes is approximately correct and the new arrangement of the microsomes around 64 centers as shown in the diagram is not violently schematized. The same is true of the size, color and disposition of the chromatoid bodies. For simplicity the spermatidian tissues are reduced in the diagram to masses of 64 and 128 nuclei respectively.

The features accompanying and following the oöcytic synapsis seem at least a gesture toward the path followed in the spermatogenesis, but they have not yet been carefully studied.

Occasion for staining the gonads of *Spirina parasitifera* offered an opportunity for a more careful study of the unicellular glands of this species that "empty" through minute pores in the cuticle of most regions of the body, but particularly along the lateral fields. Unicellular structures of this character are known to be widespread among nemas, having been recorded for a great variety of free-living genera and a few parasitic genera. It is not known whether the various unicellular organs of this character hitherto recorded are homologous or whether they are connected with a variety of functions. The fact that they are well developed on aquatic forms that experiment proved to be in urgent need of oxygen has led the writer to suggest the possibility that these "glands" or some of them, may be connected in some way with respiration. This would seem in accord with the failure hitherto to observe any such organs in the

vast majority of the parasitic species,—whose "respiration" it would seem natural to explain in other ways.

In *Spirina parasitifera* these organs are very small, and it therefore seems not unlikely that the present methods, when applied to more suitable material, may give results much more detailed and intelligible. The structure of one of these glands of *S. parasitifera*, so far as determined, is shown in Figs. 15 and 16. The great difference in the size of the organs in the two cases, as well as the difference in structure and space relationships, suggests the probability that the shape of the organ changes materially, perhaps rapidly, under various conditions. To this surmise it may be added that the method of collecting the spirinas, and the varying length of time between their existence under natural conditions and the time of examination, would result in a very material alteration in the environment; and it is believed that the longer this time became the less free oxygen would exist in the sea water in which the specimens were kept. This length of time varied widely.

SIZE AND NUMBER AS RELATED TO ORGANISMS

The interesting behavior of the spermatidian granules as described on pages 38 to 41 has suggested the following sketchy discussion of the relationship of organisms to size and number.

Why not vertebrates a mile long and a thousand feet high? Why not vertebrates only a quarter of an inch long? The known facts clearly indicate limits in both directions.

Among the reasons for the existence of the upper limit are, circulation difficulties due to friction in the blood vessels; accumulation of an excess of excreta in the blood during the long journey to the distant extremities and back; the difficulty of maintaining the requisite temperature at the extremities; limits set by the strength of materials,—bone could not be strong enough or muscles efficient enough properly to support and move so large an organism; food supply difficulties; space limitations connected with protecting such an organism from the elements, etc., etc.

Reasons for the non-existence of exceedingly small vertebrates also come readily to mind. The complicated vertebrate mechanism would be in the way in an organism of such small size. Why an elaborate pumping system to pump blood for a distance through which it might diffuse without such a system? So with "centralized" respiration. An internal skeleton plus the necessary protective

cuticle become incompatible in this range of sizes. The competition of such imaginary small vertebrates with other organisms, say insects, of simpler structure better adapted to such small sizes would be a hopeless struggle.

Why not insects as large as moles or as small as microbes? Here again the mechanical relations of the organism to the menstrua furnish numerous reasons for the known size limits.

Generalizing, why not multicellular organisms beyond certain maximum and minimum limits? A little thought shows that limits are set by the relationships of particular mechanisms to the sizes and distances involved; and as size, in such cases, is a function of the number of cooperating cells, the limits are set in numerical terms. This becomes clearer when we consider our ability to represent a cellular organism by a strictly numerical expression, the bioequation,[2] and all the more certainly true when, continuing the same line of thought, we consider the size limits of cells.

Why do we not have cells a meter long; and why not typical cells below the limits of a micron or two? Again, among other reasons, in this range of still smaller sizes the mechanism of the typical cell becomes so complex as to "be in its own way" when the distances involved become sufficiently small and the number of properties to be transmitted sufficiently few, as will be indicated in a moment.

Size limits in these various cases are set by a fundamental necessity, having its "final" source in the size of the electronic combinations.

Particular attention is called to the fact that, usually, the size limits of "adjacent" higher and lower groups of organisms reciprocally overlap (e.g. Vertebrates and Insects); as well as to the fact that individuals of certain species of unicellular organisms are larger than some of the multicellulars; or, to emphasize by reversing, many multicellulars are smaller than some of the larger unicellulars. There is a distinct *lapping* of the size limits of one on to the size limits of the other.

Organisms of greater size; "social organisms."—Developing a more complex nervous system, the higher organisms have evolved "mental pictures" of distant and invisible things and events, and have invented means for transmitting through various media signs that represent these mental pictures. Along this path the social organisms evolved. When we speak of a social organism it is usually assumed

[2] *Biological Relationships of the Mathematical Series* 1, 2, 4, etc." This JOURNAL 15: 235, 1925.

that we are using analogy, but an interesting formulation might be made out for homology. Are not the interactions between relatively widely separated intellectual individuals, existing in the sea of air surrounding the earth, in many ways actually homologous with the passage of stimuli, etc., through more viscous fluid media between cells? As, for instance, when two small organisms live in symbiosis; or, where cells exist together as they do in blood; or, between cells even more intimately organized.

The concept of organisms of this higher or social grade suggests the possibility of there being also lower orders of organisms at the other end of the accepted series. This idea is not new, for their existence was specifically asserted by acute observers and adventurous thinkers in the plainest of language at least half a century ago; but at that time the supporting evidence was so meagre that the idea did not rise to the dignity of an acceptable working hypothesis. Now it is quite different. Today what we know about certain small living elements, both inside and outside of cells, compels such a working hypothesis,—if mayhap we are not already beyond the hypothetical stage.

Here again, size seems a prime determining element. When a cell (really a relatively complex and large organism) transmits its exceedingly numerous properties to its "descendants," nothing short of an elaborate mobilization and census is adequate to the coming transmigration. Hence follow mitosis and its complications.

We are perhaps prone to forget that every cell has, in a great degree, to care for itself; and so *must* have many of the multitudinous properties characteristic of the groups of cells constituting higher organisms. It *must* nourish itself. "You can take the horse to food (or vice versa), but you cannot make him eat;—he must do that himself," seems to summarize the situation. If the cell assimilates ("eats"), and is to continue, then it must have mechanism adequate to select, transport, digest, excrete, etc., and at least to take some part in reproducing itself. All this complexity is because of the *number* of its characteristics, and because of the size, i.e., the distances involved. But what if all these be a hundredfold or more reduced, and the system be at the same time "isolated" or individualized? Plainly, the requirements would call for a simpler mechanism; cell-mechanism would be so complicated as to be in the way. Under such conditions simpler organisms, organisms simpler than cells, seem a logical necessity.

Litobionts.—I have ventured to suggest a general or inclusive name, Litobionts, for the organisms which my observations lead me to believe to exist, these very organisms of lower grade;—(λιτος, simple), simple-organisms. The Litobionts have distinctive characters, such as small size, and simplicity of composition, but nevertheless, live, assimilate, grow, multiply;—not only segmenting somewhat after the manner of some higher, more or less filamentous organisms, but *multiplying by endogenous division*, this latter being one of the present observations, the endogenous process being exemplified in the "granules" of the spermatidia of *Spirina*. (See p. 41.)

Yet it is possible to over-emphasize the smallness of Litobionts. It seems likely that we have been looking at Litobionts a long time,—Litobionts of the larger size,—without recognizing their nature, just as observers previous to the time of Schleiden and Schwann had been looking at cells without recognizing their nature.

Just as the multicellular and unicellular organisms overlap each other in the matter of size, so the unicellular organisms (having the characteristic properties of cells as now defined) overlap the Litobionts. There are unicellular organisms smaller than some Litobionts. Or, in reverse, some Litobionts larger than some unicellular organisms.

That the Litobionts are much simpler than cells, is indicated by a number of considerations. Their effects on light indicate that in the main, they are composed of a smaller number of kinds of molecules of a more orderly arrangement,—what may perhaps be thought of as forming a simpler plasm, Litoplasm. The fact that some of them are soluble in certain chemical reagents (e.g. acetic acid), is another indication of relative simplicity. In a word, we must conceive of the Litobionts as made up of a smaller number of kinds of simpler molecules manipulated through very much smaller distances, and therefore necessarily (a matter of "economy," "least resistance") by simpler mechanism. It is quite conceivable that some Litobionts may be smaller than some of the largest molecules. Not needing these large and complex molecules, the mass of the Litobiont may even be smaller than that of some such molecules.

The duality characteristic of all matter must lead, however, to an arrangement of the parts in Litobionts such that we can only think of them at present largely in terms of what we know of cell physiology and mechanics; simply because knowledge progresses exclusively through the known to the unknown. Our knowledge of cells must be one of the main sources of our Litobiont concepts.

We may at least suspect the existence of organisms, or quasi-organisms, simpler than Litobionts. Is not a living "being" composed of a comparatively small number of chemical elements, say approaching some of the carbohydrates in composition, not only thinkable, but are there not experimental data almost justifying science in its present state in postulating such "beings"?

SCIENTIFIC NOTES AND NEWS

The third meeting of the International Union of Scientific Radio Telegraphy held at Washington from October 10 to 28, 1927, was the largest and most successful of the three that have taken place up to the present time. The first was held at Brussels in 1922. The Washington meeting included both general sessions and sessions of its technical subdivisions called "commissions" and was arranged according to the following program:

Oct. 10, General Session
11, Commission II, Wave Propagation
12, " I, Radio Measurements
13, Public Session
14, Commission III, Atmospherics
17, " II, Wave Propagation
17, " IV, Liaison
18, " I, Radio Measurements
18, " III, Atmospherics
20, " III, "
20, " IV, Liaison
24, " I, Radio Measurements
26, " II, Wave Propagation
26, " IV, Liaison
27, " III, Atmospherics
28, General Session.

The public and general sessions were held under the chairmanship of Gen. Ferrié, President of the Union. The presiding officers at the session of the commissions were as follows: I, Radio Measurements, Dr. D. W. Dye (England); II, Wave Phenomena, Dr. L. W. Austin (U. S. A.); III, Atmospherics, Prof. R. Mesny (France); IV, Liaison, Prof. G. Vanni (Italy).

The papers presented in the public session, October 13, were as follows:

L'emploi de cellules photoélectriques associées à des lampes à plusieurs électrodes, à la solution de divers problèmes concernant la mesure du temps. Gen. G. Ferrié.

International comparison of frequency standards. Dr. J. H. Dellinger,

The Navy's primary frequency standard. R. H. Worrall and R. B. Owens.

Precision determination of frequency. J. W. Horton and W. A. Marrison.

A radio-frequency oscillator for receiving set investigations. G. Rodwin and T. A. Smith.

The effect of reaction on the received signal strength. Dr. B. van der Pol.

An automatic recorder for radio signals and atmospheric disturbances. E. B. Judson.

Experiences in radio compass calibration. F. A. Kolster.

Apparent night variations in crossed-coil radio beacons. H. Pratt.

Investigation of downcoming waves (a) on the existence of more than one ionized layer, (b) on the influence of the earth's magnetism on wireless transmission. Prof. E. V. Appleton.

Ionization in the upper atmosphere. Dr. E. O. Hulburt.

A theory of the upper atmosphere and meteors. H. B. Maris.

Les ondes ultra-courtes. Prof. R. Mesny.

Experiments on radio wave projectors. E. F. W. Alexanderson.

Height of reflecting layer in August 1927 and the effect of the disturbances of August 19. O. Dahl and L. C. Gebhardt.

The relation between radio reception, sunspot position and area. G. W. Pickard.

On the influence of solar activity on radio transmission. Dr. L. W. Austin and Miss I. J. Wymore.

Seasonal variation in signal strengths of the 20-meter wave from Nauen in Japan. T. Nakagami and T. Ono.

Diurnal variation in signal strengths of short waves. T. Nakagami and T. Ono.

A note on the short-wave long-distance transmission. T. Minohara and K. Tani.

The directional observations on atmospherics in Japan. E. Yokoyama and T. Nakai.

Relations entre les parasites atmosphériques et les phénomènes météorologiques. Capt. R. Bureau.

The meetings concluded with a formal dinner tendered to the visiting delegates by the executive committee of the American section on October 28. The persons who attended the meetings from the various countries were as follows:

Australia; Prof. J. P. V. Madsen.

Belgium; Prof. R. B. Goldschmidt.

Canada; Major W. A. Steele, J. W. Bain.

France; General Ferrié, P. Brenot, Dr. LeCorbeiller, Comm. Jullien, Prof. R. Mesny, Capt. Bion, Capt. R. Bureau.

Germany; Dr. H. Harbich.

Great Britain; Prof. E. V. Appleton, Dr. D. W. Dye, E. H. Shaughnessy, Capt. P. P. Eckersley, Capt. A. L. Harris.

Holland; Dr. B. van der Pol, E. F. Volter, G. C. Holtzappel, G. Scholet.

India; T. G. Edmunds.

Ireland; T. S. O'Muineachain.

Italy; Prof. G. Vanni.

Japan; Capt. T. Minohara, Prof. E. Yokoyama, T. Nakagami, S. Inada.

Norway; H. Petersen.

Switzerland; E. Nussbaum, H. Eggli.

United States of America; Dr. L. W. Austin, E. F. W. Alexanderson, Dr. R. Bown, Dr. G. Breit, Major W. R. Blair, Miss M. A. Brower, Prof. W. G. Cady, Dr. J. H. Dellinger, F. W. Dunmore, O. Dahl, Dr. H. T. Friis, Dr. E. O. Hulburt, E. L. Hall, Dr. A. Hund, J. W. Horton, V. E. Heaton, E. B. Judson, Dr. C. B. Jolliffe, S. S. Kirby, Prof. A. E. Kennelly, F. A. Kolster, G. W. Pickard, T. Parkinson, H. Pratt, Gen. C. M. Saltzman, Gen. G. O. Squier, Dr. G. C. Southworth, Dr. A. H. Taylor, Prof. E. M. Terry, Dr. Tuve, Dr. W. Wilson, Dr. L. P. Wheeler, Miss I. J. Wymore.

On December 6th Neil M. Judd, Curator of American Archeology, United States National Museum, returned to Washington after six months field work for the National Geographic Society at Pueblo Bonito. Pueblo Bonito is a prehistoric Indian village in northwestern New Mexico and is the most remarkable of all the pre-Hispanic pueblos of the Southwest. The past summer marked the seventh and concluding season of The Society's explorations. Mr. Judd is now engaged upon preparation of his final reports which will be published by The Society.

The Petrologists' Club met at the Geophysical Laboratory on December 20. Program: W. F. FOSHAG, *The hematite (martite) deposit at Durango, Mexico;* C. P. ROSS: *Some aspects of magnetite-specularite intergrowths.* J. W. GREIG presented an informal communication on *The supposed evidence for liquid immiscibilty in rocks at Agate Point, Ontario.*

Representative SINNOTT introduced in the House of Representatives on December 15 (by departmental request) a bill (H.R. 7480) "To authorize the transfer of the geodetic work of the Coast and Geodetic Survey from the Department of Commerce to the Department of the Interior." The bill makes the Geological Survey responsible for the execution of geodetic surveys in the interior of the United States, including also variation-of-latitude, gravity, and seismological observations. The Coast and Geodetic Survey would be renamed the "United States Coast Survey." The bill was referred to the Committee on Interstate and Foreign Commerce.

On January 10 Dr. CHARLES G. ABBOT was elected Secretary of the Smithsonian Institution by the Board of Regents. Dr. ABBOT had been Acting Secretary since the death of Dr. WALCOTT.

Professor H. H. BARTLETT of the University of Michigan spent a few days preceding and following the Christmas meetings of the Botanical Society of America at the National Herbarium, preparing for distribution his botanical collections of 1926–27 from Formosa and Sumatra. The most complete sets are going to the U. S. National Herbarium, the University of Michigan, Dr. E. D. Merrill, and the Gray Herbarium.